The difference of the rms sizes of neutron and proton distributions: comparison of theory with data

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Recent measurements on antiprotonic atoms [1] have improved significantly the available information on the neutron-to-proton density ratios in the tails of nuclear density distributions. Using certain reasonable assumptions, backed by Hartree-Fock calculations, these ratios have been converted into differences of the rms radii, Δ, between the neutron and proton density distributions for nuclei ranging from ^{12}Ca to ^{238}U. Such rms differences have been the subjects of many theoretical speculations since the fifties. In 1980 the droplet model of average nuclear properties was used to derive a closed algebraic formula for Δ as a function of the neutron and proton numbers N and Z [2]. The formula contains two droplet model parameters: the symmetry energy coefficient J and the surface skin stiffness coefficient Q, as well as a term proportional to the difference between the neutron and proton surface diffusenesses. Using the standard values J=32.65 MeV and Q=35.4 MeV from [3], and assuming the neutron and proton surface diffusenesses to be equal, an approximate agreement with the trend of the measurements is obtained. By allowing the neutron diffuseness to be somewhat greater, perfect agreement with data can be achieved. There is then also perfect agreement between the algebraic droplet model formula and numerical Hartree-Fock calculations of Δ. At a deeper level, however, there appears to be a difficulty in reconciling the droplet model and the Hartree-Fock interpretations of the measurements. Although the values of Δ are reproduced in both approaches, the former attributes the effect mostly to a difference in the neutron and proton radii and the latter largely to a difference of the surface diffusenesses. The reason for this apparent discrepancy is being investigated. An article for submission to Phys. Rev. C has been prepared [4].

[1] A. Trzcinska et al., *Neutron density distributions deduced from antiprotonic atoms*, Phys. Rev. Lett. **87**, 082501 (2001).
[2] W. D. Myers and W. J. Swiatecki, Nucl. Phys. **A 336**, 267 (1980).
[3] W. D. Myers and W. J. Swiatecki, Nucl. Phys. **A 601**, 141 (1996).
[4] W. J. Swiatecki, *The difference of the rms sizes of neutron and proton distributions in nuclei: comparison of theory and data*, to be submitted to Phys. Rev. C.